Pat.Ap.# 10/623,787 ("Radial-hinge Mechanism" – **RhM**) start: August 5, 2006
Pub.No.: US 2005/0016109 A1 1st printing: Aug.13th
Filed: July 21, 2003 (9 pages)

Synopsis of the Patent Application:

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Note: everything within quotation marks is verbatim from application.

ABSTRACT (150 words):

Basically describes the **RhM** (Radial-hinge Mechanism).
Basically describes its signature function -- its "variable nature"...
Makes note of its susceptibility to "spring-biasing techniques".
Generally lists applications from support frameworks to devices to apparatus.
Makes note of its "stacking" potential... and "casting in arrays"...
Makes note of its potential to interface with various "forms and attachments".

BACKGROUND OF THE INVENTION (5 paragraphs, 0001-0005):

Directs attention to the **RhM** as:

"a radial-hinge mechanism that includes a plurality of elongated interwoven elements"

Compares the **RhM** with five other U.S. Patents:

1. #4,731,962 -- "Compression-tension Strut-cord Units for Tensile-integrity Structures", by Kittner and Quimby, issued: Mar.22, 1988.
2. #3,546,049 -- "Symmetrical Non-Cartesian Multiple-axis Joining of Beams", by John M. Kostick, issued: Dec.8, 1970.
3. #3,830,011 -- "Deformable Tubular Rods with Deformable Sheet Material Connectors", by S. Ochrymowich, issued: Aug.20, 1974.
4. #4,259,790 – "Self-adhering Sticks, Plates and Other Educational Devices for Constructing Letters, Figures, Designs and the Like" by B. Borisof, issued: Apr.7, 1981.
5. #D 238,840 (Design patent) -- "Table" by Cesare Cassina, iss.: Feb.17, 1976.

Conclusion: "these structures are not capable of radial-hinge movement nor do their completed forms result in unitized continuous-loop frameworks that evenly distribute loads, transfer forces, and assist or resist with various spring-action potentials."

SUMMARY OF THE INVENTION (7 paragraphs, 0006-0012):

A **RhM** is based on specific "design parameters"; another description given.
These "parameters" also applying to "a vast family of radial-hinge mechanisms".
Embodiments "providing versatile mechanisms for a multitude of novel applications across a wide range of products and forms".
An alternative to the conventional coil spring.
"Spring-biasing techniques" add further to the **RhM's** usefulness; as also its "radially-pivoting motion" is achieved without requiring "the usual brackets and hardware of conventional hinge forms".
The **Rhm** "may also be interconnected with similar mechanisms along compound

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points of common intersection"... "yielding a ***stacked*** configuration". There are also "likely opportunities for radial-hinge mechanisms interfacing with encasements and bellows, propellers, blades, fins, shafts, etc."

BRIEF DESCRIPTION OF THE DRAWINGS (67 paragraphs, 0013-0079):

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1. Twelve-spoke **RhM** at 5-arcs/chord with twelve screw-on spoke-end connectors for a rigid interconnection... also pointing out the "inner-aperture", "outer circumference", and "hinge-core".
2. "Opening" and "Closing" aspects of a 12-spoke **RhM** equipped with twelve spoke-end connectors for a non-rigid interconnection.
3. Illustrating the translocatable "hinge-core" on a 12-spoke **RhM**. Also showing three unique kinds of spoke-end connectors:
   a. rigid-connecting screw-on spoke-end connector 104
   b. non-rigid-connecting push-on spoke-end connector 404
   c. variably-connecting double-clip connectors 900
4. Showing typical spoke used with rigid-connecting screw-on connectors 104 Also showing a pair of obtuse-shaped and adorned spokes (**Fig.13**) to suggest one plethora of possibilities for **RhM** spoke forms and designs. Displaying three other versions of **RhM** -- a 14-spoke and two 16-spoke versions. **Figs 15 & 16** each being composed from a single length of elongate stock and each mechanism interconnected at only one point, 1505 and 1605 respectfully.
5. Partial chart for **RhMs** -- spoke counts plotted against arc-counts/chord, indicating all versions of **RhMs** from 8-spoke to 26-spoke. 26 versions. Illustrating the typical spiraling right-hand and left-hand configurations inherent in all **RhMs** ÷ a 16-spoke @ 7-arcs/chord stripped down to create these graphic representations in Figs. 18 and 19.

6 - 8. A series of drawings involving Figs. 20-26... used in the process of designing the pattern for a 16-spoke **RhM** @ 7-arcs/chord -- and resulting in **Fig. 26**

9. A 12-spoke **RhM** (with non-rigid spoke-end connectors) depicted in various arrangements to illustrate **RhMs** use in rigid and semi-rigid applications.
10. A 12-spoke **RhM** employed to realize a number of practical apparatus of the rigid and semi-rigid sort.
11. "Stacking" 12-spoke **RhMs** together... compounding their properties and capacities. Also showing two methods and means for interconnecting the **RhMs**:
    a. with cap connectors in conjunction with coil springs 4203
    b. with double-capped inter-hinge connectors 4504
12. A single 12-spoke **RhM** interfaced with a single bellows insert, followed by a multiple situation of four 12-spoke **RhMs** stacked together to interface with four interconnected bellows inserts to realize a multiple bellows apparatus.

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13. A single 12-spoke **RhM** ensconced in wheel halfs to realize a novel radial-hinge wheel apparatus.
A single 12-spoke **RhM** used in an axle-clutching/braking apparatus.
A single 12-spoke **RhM** interfaced with fan, turbine, prop blades, etc.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT(S)
(73 paragraphs, 0080-0152):

Preface (0080-0081):

(0080): **RhM** described to be similar to a scissor-hinge. **RhM** includes a translocatable hinge-core. **RhM** "based on unique geometric design-parameters, which also apply to a vast family of **RhMs.**" And the viability of any one version of an **RhM** will depend only on its "material and dimensional limitations".

(0081): A synopsis description of **Figs 1-16,** including all the parts and forms of the essential **RhM** along with a visual on its "opening" and "closing".

A. Spokes, Peripherals Points, and Parallel Planes (0083-0093):

(0083): Why call them "**spokes**"? Include "struts, arms, legs, rods, sticks, spars, tubes, links, beams, poles, levers, members, etc."

(0084): The **spokes** 102 of **Figs. 1-3**... concisely described. The call for "achieving a three-dimensional mechanism out of a two-dimensional design-space"... and thanks to "elasticity".

(0085): Advantages of **spokes** having cylindrical cross-sections, notably generating less friction, and thence the preferred shape for the Figs. in this patent disclosure. Although other utilizations may prefer non-straight spoke forms and non-consistent spoke cross-sections -- see **Fig. 13.**

(0086): Discusses advantages of smooth spokes, or lubricated. Or requiring more friction in some cases. Reviews kinds and sorts of materials that spokes can be made from.

(0087): Discusses rigid spokes and forces involved. Also the use of thinner spokes. Reverse-biasing of spring-action again noted.

(0088): "Inconsistent spoke-lengths may be desirable in certain applications" but will also disrupt the basic and stock **RhM** feature of *peripheral-points* occupying two parallel planes.

(0089): Describes *peripheral points*. In short: "a loose designation for a location where the pathway of one spoke turns into the pathway of an adjoining spoke".

(0090): "It should be appreciated that **RhMs** have no specific requirement to limit their multidimensional frameworks to only parallel-plane displacements of their plurality of *peripheral points* even though their initial design pattern is founded on the parallelism..."

(0091): All **RhMs** generally apply to the rule of an equal number of spokes to

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the number of *peripheral points*... but not always, as is further described here. Also discuss the use of tubular spokes, and **RhMs** made from tubes linked together by an inner elastic cord, like modern tent poles. Also tubes that can be telescoping cylinders.

(0092): "Various types, sizes, shapes, forms and specialties in *spoke-design* may be utilized... and the spokes may have connections made anywhere along their bodies.... The spokes may also be carriers of other useful alterations and/or attachments, consisting of tools, fixtures, collars, levers, arms, etc." Ref. to **Figs 13 & 14**.

(0093): Discusses **RhMs** made from single lengths of elongate material woven into a fully formed **RhM** connected at just one point. Note **Figs 15 & 16**. Also distinguishes "spokes" and "spoke links".

B. Connections and Connectors (0095-0103):

(0095): "There is only one connection to be made on a **RhM** comprised of just one elongated member." Other embodiments, however, will have more than one connection point. Again discuss connecting sorts and kinds... in "adjoining spoke-ends together loosely, rigidly, variably and/or by the implementation of one of a vast species of spoke-end connectors."

(0096): Describe **Figs 1-3**... with screw-on-cap spoke-end connectors 104 -- this type of connector resulting in a relatively rigid **Rhm** framework.

(0097): Discuss "solidly-interconnected **RhMs**". Note "spiral torsion" in spokes. With conclusion: "In contrast, **RhMs** interconnected with connectors that allow twist to occur within their grasp are also mechanisms that open more easily and to a greater extent."

(0098): Note **Figs. 4a-4f**. Employing different spokes 402 and different spoke-end connectors 404 from that in **Figs. 1-3**, to herein realize a more flexible **RhM** which fully "opens" and "closes". Spoke-end connectors herein color-coded (black and white) for illustrative purposes: "to enhance understanding of the balanced distribution of the peripheral points and their relationship in all views of the **Rhm** in Figs. 4 & 5."

(0099): Discuss the looser-fitting spoke-end connectors 404... allowing the **RhM** to fully "open" with relative ease. "But... in some applications, it may be desirable to limit movement to a middle range, or more, or less." Emphasize direct correlation that material properties of its components influence the properties of the **RhM's** performance.

(0100): Note Figs. 7 & 8. Discuss in detail the spokes 402 and connectors 404 of Figs. 4a-5b... what they're made of and how they fit together for a loose or elastic action. Concluding: "The desired application of any **RhM** will generally help predetermine properties of its immediate components, with due recognition to the fact that certain properties achieved by spoke alteration may also be achieved by a variety of connector alterations."

(0101): Spoke-end connectors may also be temporary components, aiding with the construction of an **RhM** but then removed to allow spoke-ends to be

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connected into another medium. This process applicable to Fig.34.

(0102): Note Figs. 9-11b. Describe and discuss double-clip connector 900 -- "providing a universal spoke-connector for **RhMs;** a connector which may also be altered for special applications."

(0103): Procedures for constructing **RhMs** may very -- "In all likelihood, a high level of skill in the art of radial-hinge assembly will lead to shortcut-methodology for constructing a **Radial-hinge Mechanism.**" And "many other special connectors may be utilized, some to work with more than two spokes, some to have other actions built into them..."

C. Inner-Aperture/Outer-Circumference, Opening the Radial-hinge (0105-0108):

(0105): Ref. again to **Figs. 4a-4f.** Figs illustrate "full and common transformational nature from its [**Rhm's**] minimum to maximum range of operation." Also note changes to *inner-aperture* and *outer-circumference* over this range... "contracting" or "dilating"

(0106): Again ref. to **Figs 4a-4f.** Still discussing changes in the *inner-aperature* and *outer-circumference* with **RhM** movement. Conclusion: "Specifically, the **RhM** changes from one that can be contained in a flat disk-shaped form to one that can be contained in a long tubular form."

(0107): Explaining the logic of what constitutes an "open" or "closed" state for the **RhM.** Finally: "given the perspective of a radial-hinge acting as a linkage between two generally parallel surfaces, this linkage is closed when the two surfaces are closest together (in something akin to **Figs 53a-b**).

(0108): "Finally, there is the hinge itself, the arrangement that makes for the **RhM;** the provider of the radial-hinge-action and more or less centralized on the core inter-braiding of the intersection of the mechanism's plurality of spokes." -- Thus "it is the full-interconnectedness of this assembly which constitutes the singular thing called a 'hinge'." Also disccuss "potential to laterally translocate" the hinge-core. All in all, this **RhM** relates to a kind of radial scissor-hinge.

D. Design and Construction of a Radial-hinge Mechanism (0110-0124):

(0110): "The current invention can be thought of as a three-dimensional mechanism composed directly off the pattern of its embodiment in two-dimensional space." Discuss the choosing of a "spoke count" and "arc count" before designing any version of the **RhM** -- these parameters cross-referenced in Chart of **Fig.17** -- wherein *'dashes'* in the cross-reference indicate **RhMs** that ***cannot*** be built. Chosen for the following design and assembly procedure: a 16-spoke **RhM** at seven arcs/chord.

(0111): Discuss **Fig. 18** -- a skeltonized representation of a 16-spoke **RhM**... to emphasize the unique spiraling design-feature built into the **RhM.** Etc.

(0112): Discuss **Figs. 18 & 19** together -- one side of a **RhM** being the mirror

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opposite of its other side, etc. More on *left-handedness* and *right-handedness* in the **RhM** designs and forms. "It should be appreciated that both design approaches lead to the same result."

(0113): Note **Figs. 20 & 21**. Creating the rudimentary line-drawing in the first steps to design on paper a 16-spoke **Rhm** at seven arcs/chord.

(0114): Note **Fig. 22**. Filling in the chords of **Fig.21** to distinguish spokes of the emerging mechanism. Identify foreground *peripheral points*.

(0115): Note **Fig. 23**. Using the signature spiraling form discussed over **Figs. 18 & 19** to lay down the seminal step in making the **RhM** design.

(0116): Note **Fig. 24** -- which is the result of installing the seminal pattern of **Fig. 23** into the scheme of **Fig. 22.**

(0117): Note **Fig. 25** -- which resolves the remaining unique design parameters through the specifics of a spoke-pair and the paths they each follow through the maze of the proto-scheme in **Fig.24**. Segments of spoke are used in this **Fig.25** to represent full spokes being traversed. And: "This over/under sequence applies to all versions of **RhM** designs...."

(0118): Again note **Fig. 25**. More discussion on resolving the final design of a 16-spoke **Rhm** with seven arcs/chord, and noting: "This radial-spiral symmetry is indicative of all **RhMs**". Also discuss "layering" and direct correlation with "arc-count per chord".

(0119): Note **Fig. 26** -- the final resolution of all the like paths of the remaining spoke-pairs: the initial design and pattern for a 16-spoke **RhM** with seven arcs/chord. Finally, the description of how to use this pattern to build the basic **RhM** of this particular version – **16/7** (16-spokes at 7 arcs/chord). And start to discuss making spokes from wooden dowels.

(0120): Note **Figs. 12a-b**. More talk on cutting dowels to mesh at spoke-ends. Computing the angle of cut at spoke-ends.

(0121): A screw-on spoke-end connector for a 12-spoke **RhM** may not be appropriate if used on a 16-spoke **RhM** -- different angles = different forms. Discuss use of off-the-shelf "twist-on wire-connectors".

(0122): "In general, **RhMs** with greater arc-counts per chord will have smaller inner-apertures... and it is expected that some versions of a **RhM** with high spoke-count and low arc-count will result... in a less resistant manner." **[In retrospect: these relationships may not be valid as first presumed].**

(0123): "All **RhMs** are based on multi-point star-designs but not all **RhMs** resemble stars or necessarily have star-points." Compare **Fig. 16** with **Fig. 26.**

(0124): "Uses and applications for **RhMs** may prove to be highly variable."

E. <u>Radial-hinge Mechanisms in Rigid/Semi-rigid Applications</u> (0126-0135):

(0126): Note **Figs. 27-54**. Discuss sheathing and coverings to interface with rigid and semi-rigid **RhM** frameworks. Discuss use of 12-spoke **RhM(s)** 400 to be the basic frameworks for **Figs. 27-54.**

(0127): "In practice... a wide assortment of other kinds of radial-hinge body-

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connectors and end-connectors, some discussed herein, may work better, depending upon the application." And improved spoke designs.

(0128): Discuss **Figs. 27-30** – illustrating typical methods of propping open **RhMs** against their resistant "closed" condition. **Fig. 27**, showing device 2700, also represents the employment of a **RhM** whose *peripheral points* do not all fall into two parallel planes. Introduce *constraining band* 2902 in **Fig. 29**. Discuss reverse-biasing again. Conclusion: "In general, the **RhM** may be sprung either way or not sprung at all, or it may have timely and variable elastic properties due to changes in temperature, changes imposed by electric or magnetic influence or other known ways to artificially influence the properties of the materials of the mechanism."

(0129): Further discussion on the *constraining band* 2902 and similar band 4702. Prominent in reverse-spring-biasing techniques, and fixing the *hinge-core*.

(0130): Note **Fig.31**. Illustrates a more solid framework than shown in **Figs. 27-30**. Make suggestions for adding a *constraining band* and/or *double-clip connectors*.

(0131): Note **Figs 32 & 33** – approaches to putting covers on **RhMs**... to realize decorative building columns, various baskets, including variations on baskets for playing basketball; also note apparatus for various kinds of musical drums as well as stacked **RhM** forms to create raceways for wires, pipes, etc.

(0132): Note **Figs. 34 & 35** -- "generally fixed-in-form radial-hinge devices". And showing how spoke-end connectors have been removed and spoke-ends directly inserted into respective disk forms. *Peripheral points* 3406 compared.

(0133): Note **Fig 35** -- looking closer at this radial-hinge device 3500. "Cages, spools, spindles, and sheaves" come out of these **Figs. 34 & 35.**

(0134): Note **Figs 36-41**. Some useful apparatus constructed from **RhMs**... and many more everyday products discussed... "Basically, anything that stands on legs may be accommodated by **RhM** designs..." Also express caution about the intrinsic hazard of the scissor-hinge action of **RhMs**.

(0135): Note Figs 36-41. These stationary forms may have some elastic give in their natures -- "a kind of bounce and/or some may be intentionally collapsible for portability or adjustability and/or intended for shock-absorbing applications. Thus, the usual parameters for solid-structure-design may not exactly apply to many of these..."

F. Radial-hinge Mechanisms in Active Applications (0137-0152):

(0137): Intro: "The **RhM** multiplies its potential usefulness when put into an active role in active devices and apparatus and, though many of these productions will only entail the inclusion of a single **RhM**, the greater variety of these active forms will be composites of two or more **RhMs** variously connected together into a stack."

(0138): Stacking first noted in **Fig. 33** in a fixed object. "In a similar fashion, a stack of **RhMs** may also be interconnected to operate cooperatively in

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active roles of extension and retraction."

(0139): Note **Figs 42a-b** -- two **RhMs** interconnected with coil-springs 4203. Discuss these connecting springs which resist and overcome the forces of the **RhM's** "closed" mode, therein keeping the stack "open" as in **Fig. 42a**. Arrows in **Fig. 42b** indicate need of external force to keep the **RhM** stack "closed".

(0140): Note **Fig. 43**. Discuss this three-high stack of **RhMs**... composed into the G-decelerator apparatus 4300. Discuss its component parts. "Similar useful apparatus will resemble this apparatus 4300 in the guise of weight-scales, vertical lifts of various sorts, trampolines, radial-catapults, gantry-arms on space vehicles, landing pods for various airborne vehicles, etc." Also suggest addition of constraining bands for greater resistance, or some kind of "break bands" that release or break with stress overloads.

(0141): Note **Figs 45 & 47**. Similar apparatus. Both two-high stacked apparatus. Both interconnected with double-capped inter-hinge connectors (**Fig. 46**) derived from push-on spoke-end connectors 404. Unlike coil-springs, these double-cap connectors 4504 pivot freely without spring resistance.

(0142): Note **Fig. 45**. Describe aspects of. Essentially -- a "prototypical arm and hand apparatus..." clutching a ball.

(0143): Note **Fig. 47**. Describe aspects of. Similar to apparatus in **Fig. 45** but including a *constraining band* and incorporating two **RhMs** of different sizes, one with its *hinge-core* translocated to accommodate the total form.

(0144): "Stacked, active **RhM** devices and apparatuses may be useful in many applications beyond the few so far mentioned and variably depicted. In the medical field alone..." List some medical apparatuses.

(0145): Suggest **RhMs** arrayed like coil springs to be useful in mattress construction. A toy set also comes to mind.

(0146): Handedness with regard to "stacking"; define two ways to stack **RhMs**.

(0147): Note **Fig. 48**. **RhMs** may be used in a range of apparatus to push air or other fluids in a bellows fashion. Discuss single bellows insert 4800.

(0148): Note **Figs 49a-b**. More discussion on insert 4800.

(0149): Note **Figs 50 & 51a-b**. A four-high stack of **RhMs** and compound bellows 5100 working in conjunction if combined. Single interface shown in **Fig. 48**. Discuss other bellows forms. List possible applications for like apparatus notably involved with hydraulic and pneumatic systems. Discuss bellows' material -- elastic? pliable? permeable or not?

(0150): Note **Fig. 52** -- wheel apparatus incorporating a 12-spoke **RhM**. Fully describe and discuss this **RhM** apparatus.

(0151): Note **Figs 53a-b**. -- a **RhM** braking/clutching apparatus. Describe and discuss. "A wide variety of forms of this application will be feasible, including arrangements using stacked **RhMs**." List several similar applications... "as well as in roles to transfer and transmit power."

(0152): Note **Fig. 54** -- an **RhM** fan apparatus. Describe and discuss. List similar apparatus ranging from boat props to windmills, or cutting-blades in various cutting operations of wood, steel, etc. And so forth.

continued...

G. Conclusion (0153-0154):

(0153): "The advantages of a **RhM** constructed according to specifications are due to its general simplicity and variable nature, both of which emphasize its uniqueness and versatility and probable application in roles and functions currently and formerly monopolized by more complex, costly devices and apparatus which generally produce the same result. In addition, irrespective of whether the **RhM** is constructed of separate spokes or segments, or including an intervening medium to realize other important radial-hinge configurations, or whether the spokes are formed as a continuous member, a **RhM** device or apparatus may be achieved."

(0154): "It is understood that the embodiments shown in the drawings and described above are merely for illustrative purposes and not intended to limit the scope of the invention..."

Compiled by G. Rouse, Aug. 5-6, 2006